CONVENTIONAL AND EMERGING TECHNOLOGY APPLICATIONS FOR UTILIZING LANDFILL METHANE: OPPORTUNITIES FOR PROJECT DEVELOPMENT IN THE METHANE TO MARKETS PARTNERSHIP

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Abstract

Methane is a primary constituent of landfill gas (LFG) and a potent greenhouse gas when released to the atmosphere. Each day millions of tons of municipal solid waste are disposed of in sanitary landfills and dump sites around the world. Globally, landfills are the third largest anthropogenic emission source, accounting for about 13 percent of methane emissions or over 818 million metric tonnes of carbon dioxide equivalent ($MMTCO_2E$).

Reducing emissions by capturing LFG and using it as an energy source can yield significant energy, economic and environmental benefits. Moreover, the implementation of landfill gas energy (LFGE) projects reduces greenhouse gases and air pollutants while contributing to energy independence and economic benefits. Internationally, significant opportunities exist for expanding LFGE and an increasing number of conventional and emerging technology applications are becoming commercially viable to target this untapped market.

Globally, LFG is currently extracted at over 1,200 landfills for a variety of energy purposes, such as: 1) generation of electricity with engines, turbines, microturbines, and other emerging technologies; 2) process the LFG and make it available as an alternative fuel to local industrial or commercial customers; and, 3) creating pipeline quality gas or alternative vehicle fuel.

With the recent launch of the Methane to Markets Partnership – a new international initiative that will reduce global methane emissions from landfills, coal mines, and natural gas and oil systems – new opportunities for project development in developing countries will be greatly expanded. In the area of landfills, the initiative centers on identifying landfill sites for methane recovery, and on promoting cost-effective electricity generation or direct use of the resource using appropriate LFG utilization technologies.

The Role of Landfill Methane in Global Climate Change and Opportunities for Methane Capture and Use in the Methane to Markets Partnership

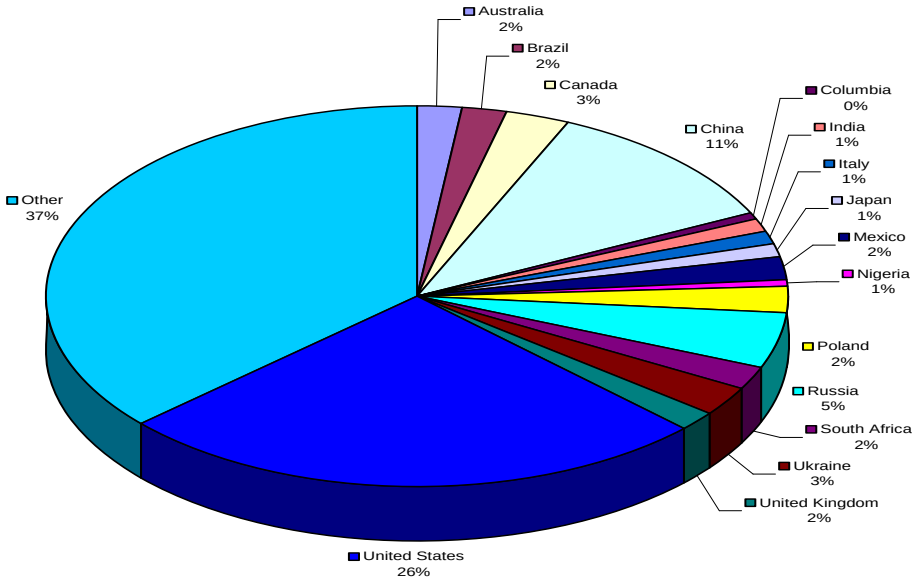
Launched in November 2004, the Methane to Markets Partnership is an action-oriented initiative that will reduce global methane emissions to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse gases. Other benefits of this partnership include improving safety, reducing waste, and improving local air quality. The initiative focuses on cost-effective, near-term methane recovery and use as a clean energy source. Central to this effort is the establishment of partnerships among developed countries, developing countries, and countries with economies in transition – along with strong participation from the private sector. Current founding country partners include: U.S., Australia, Brazil, Canada, China, Colombia, India, Italy, Japan, Korea (Republic of), Mexico, Nigeria, Poland, Russia, South Africa, Ukraine, and United Kingdom.

The Methane to Markets Partnership initially targets three major methane sources: landfills, underground coal mines, and natural gas and oil systems.[1] The focus of this paper will be on landfill methane emissions and opportunities for its capture and beneficial use.

Landfills are the third largest anthropogenic (human-influenced) emission source, accounting for about 13 percent of global methane emissions or over 818 million metric tonnes of carbon dioxide equivalent ($MMTCO_2E$). Figure 1 identifies some of the countries with significant methane emissions from landfills. Globally, the predominant global solid waste management practice is depositing solid wastes from households, commercial and industrial activities into a landfill, where methanogenic bacteria decompose the organic material. A product of the bacterial decomposition is landfill gas, which is composed of methane and carbon dioxide, in approximately equal concentrations.

In the area of landfills, the Methane to Markets Partnership centers on identifying landfill sites for methane recovery, and on promoting cost-effective electricity generation or direct use of the resource. Efforts include the identification of barriers to project development, the improvement of enabling legal, regulatory, and institutional conditions, and the creation of efficient energy markets. The active involvement by private sector entities, financial institutions, and other non-governmental organizations is considered essential to build capacity, transfer technology, and promote private investment that will ensure the Partnership's success.

Figure 1
2000 Global Landfill Methane Emissions ($MMTCO_2E$)



[1] http://www.methanetomarkets.org, Methane to Markets Website

Overview of Landfill Gas Capture and Control

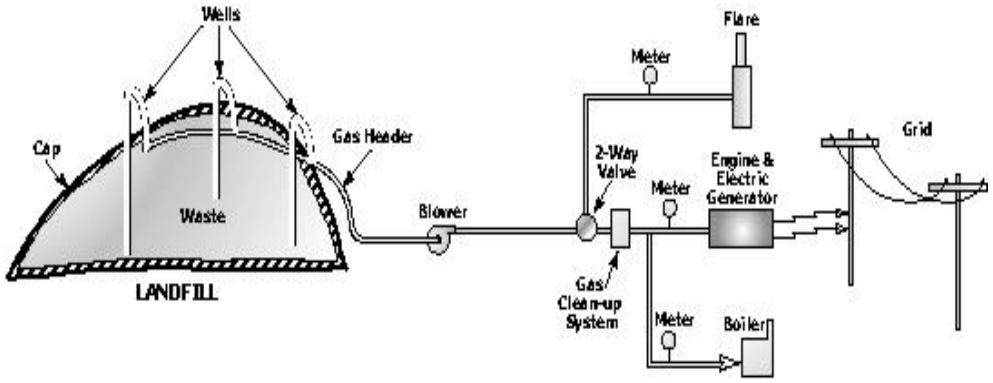
Since there is a time lapse between the initial placement of waste in a landfill and the build-up of sufficient landfill gas to justify the installation of a landfill gas utilization project, landfill gas projects almost always follow the initial construction of the landfill by several years. At smaller landfills, many landfill gas utilization projects are installed near or after the close of the landfill, which may be after 20 or 30 years of operation. In many developing countries, due to the high organic fraction of the waste stream, placement of LFG collection and control may be initiated earlier due to rapid decomposition of the organic fraction, and a resulting increase in the generation of methane over a shorter timeframe.

If the sole objective of a landfill project is to destroy the methane and other components of landfill gas, landfill managers commonly select a combustion flare for the project technology. If there are markets for electricity in the vicinity of the landfill, an electric generator powered by a combustion turbine or reciprocating engine using landfill gas will generally be the selected technology. If there are industrial markets for process heat near the landfill, the selected technology may be a boiler, heater, or kiln using landfill gas. Since landfill gas can be a health and safety problem in confined spaces, most projects that produce electricity or process heat include a flare in their design to safely combust the collected gas during periods when the primary project technology is down for repair and maintenance.

A common method of controlling methane emissions from landfills is to install a gas collection system in the landfill to collect and convey the methane to a gas control system. Figure 1-1 depicts a landfill with a gas collection and control system. Landfill gas is extracted from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending upon the ultimate use for the gas. The landfill depicted in Figure 2 is applying three methane control technologies: flaring, electrical generation with an engine or turbine, and combustion in a boiler. However, most landfills will apply only one or two of these methods.

Instead of allowing LFG to escape into the air, it can be captured, converted, and used as an energy source. Using LFG helps to reduce odors and other hazards associated with LFG emissions, and it helps prevent methane from migrating into the atmosphere and contributing to local smog and global climate change.

Figure 2: Illustration of Landfill Gas Collection System and Gas Destruction Systems



Types of Landfill Gas Utilization Projects

Table 1-1 lists the types of landfill gas projects that have been implemented at landfills in the last few years, both in the United States as well as globally. The projects that produce a beneficial product such as electricity or process heat from landfill gas should be viewed as two projects: a project that is reducing methane emissions from the landfill and a project that is using renewable energy to offset greenhouse gas emissions from fossil fuel combustion.

Table 1-1
Types of Typical Landfill Gas Capture and Use Applications

Landfill Caps	Electricity Generation	Fuel Production
• Soil caps • Clay Caps • Geomembrane caps LFG Destruction • Flares (candlestick and enclosed)	• Reciprocating Engines • Combustion Turbines • Microturbines • Steam Turbines • Fuel Cells Combined Power • CHP- Turbines • CHP- Engines	• Medium BTU Gas • High BTU Gas • Liquified Methane Thermal Generation • Boilers • Kilns • Greenhouse Heaters • Leachate Evaporators

Landfill Gas Electricity Generation

The generation of electricity from LFG makes up over two thirds of the currently operational projects internationally. Electricity for on-site use or sale to the grid can be generated using a variety of different technologies, including internal combustion engines, turbines, microturbines, Stirling engines (external combustion engine), and Organic Rankine Cycle engines. The vast majority of projects use internal combustion (reciprocating) engines or turbines, with microturbine technology being used at smaller landfills and in niche applications. Certain technologies such as the Stirling and Organic Rankine Cycle engines are still in the development and pilot demonstration phase.

Direct Use of Landfill Gas

Directly using LFG to offset the use of another fuel (natural gas, coal, fuel oil) is currently utilized in boilers, dryers, kilns, greenhouses, or other thermal applications. It can also be used directly to evaporate leachate. Innovative direct uses include firing pottery and glass blowing kilns; powering and heating greenhouses and an ice rink; and heating water for an aquaculture operation. Current industries using LFG include auto manufacturing, chemical production, food processing, pharmaceutical, cement and brick manufacturing, wastewater treatment, consumer electronics and products, paper and steel production, and prisons and hospitals, just to name a few.

Other Uses of Landfill Gas

Some additional uses include cogeneration (also known as combined heat and power or CHP) projects using LFG generate both electricity and thermal energy, usually in the form of steam or hot

water. Several cogeneration projects have been installed at industrial operations, using both engines and turbines. The efficiency gains of capturing the thermal energy in addition to electricity generation can make these projects very attractive. Production of alternate fuels from LFG is an emerging area. Landfill gas has been successfully delivered to the natural gas pipeline system as both a high-Btu and medium-Btu fuel. Landfill gas has also been converted to vehicle fuel in the form of compressed natural gas (CNG) and liquefied natural gas (LNG) projects in the planning and demonstration stages (e.g., Rome, Italy; Burlington County, USA; Iceland).[2]

Opportunities and Challenges in Developing Landfill Gas Projects

One important issue for project development is that open dumps and unmanaged landfills are the predominant disposal options in many developing countries. These sites can be less than optimal candidates for LFG energy development due to small amounts of methane (resulting from aerobic degradation and rapid waste decomposition). However, many developing countries are currently transitioning to landfills from more uncontrolled systems. Landfills will provide a more environmentally sound disposal option for these countries, but they also will produce more methane. The Methane to Markets Partnership can help facilitate a transition to landfilling by sharing information on effective landfill design and management, and how to integrate landfill methane capture and beneficial use into these planning processes.

Another important issue for LFG energy project viability in both developing and developed countries is energy price structure. Government policies on energy and solid waste management can promote or hinder the beneficial use of LFG. An uncertain regulatory environment is often a concern among potential investors. For example, project developers can be subject to different and sometimes conflicting laws at the local, regional and national levels. Moreover, a lack of regulations governing landfills and LFG energy projects (i.e., no requirement or incentive to collect and combust LFG) in some countries can inhibit project development.

As countries begin to implement laws, regulations, and policies to improve solid waste management practices, promote alternative energy, and address greenhouse gas emissions, the economic viability of LFG energy projects will improve. Moreover, creating an atmosphere where potential investors (private sector, international development banks, and financiers) are secure in the technical and policy framework that supports LFG energy projects will be essential to project development.

The Methane to Markets Partnership will bring together the collective resources and expertise of the international community to address technical and policy issues and facilitate LFG energy projects. Early initiatives will likely include:

- Assisting with solid waste management capacity building,
- Identifying potential landfill resources,
- Performing initial gas generation and feasibility studies.[3]

Environmental Benefits of Landfill Gas to Energy Projects

Reducing methane emissions has many important energy, safety, economic, and environmental benefits. First, because methane is both a potent greenhouse gas (GHG) and has a short atmospheric lifetime, methane reductions can produce significant near-term results. In addition, methane is the primary constituent of natural gas. Thus, the collection and utilization of methane provides a valuable, clean-burning energy source that improves quality of life in local communities and can generate revenue and improve living standards. Producing energy from recovered methane can also avoid the use of higher-emitting energy resources such as wood, coal or oil. This can reduce end user

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[2] Ibid

[3] Ibid, Recovery and Use of Methane from Landfills

and power plant emissions of CO_2 and air pollutants such as sulfur dioxide (which is a major contributor to acid rain), particulate matter (a respiratory health concern), and trace hazardous air pollutants. Capturing methane from coal mines can also improve safety conditions by reducing explosion hazards.[4]

Conclusion

Using LFG for energy is a win/win opportunity. Landfill gas utilization projects involve citizens, non-profit organizations, local governments, and industry in sustainable community planning and create partnerships. These projects go hand-in-hand with community and corporate commitments to cleaner air, renewable energy, economic development, improved public welfare and safety, and reductions in greenhouse (global warming) gases. By linking communities with innovative ways to deal with their LFG, Methane to Markets Partnership will contribute to the creation of livable communities that enjoy increased environmental protection, better waste management, and responsible community planning.[5]

[4] http://www.methanetomarkets.org/, Methane to Markets Web site

[5] www.epa.gov/lmop Landfill Methane Outreach Program Web site.